Probabilistic Reliability Modeling Inputs and Assumptions

RA Workshop | November 26, 2013 | Donald Brooks | Joanna Gubman

California Public Utilities Commission

Agenda

11:00 – 11:10	Introductions and announcements
11:10 – 11:30	Introduction to SERVM reliability calculator
11:30 – 12:15	Regions and weather
12:15 – 1:00	Neural networks, load shapes, and wind/solar production profiles
1:00 – 2:00	Lunch
2:00 – 2:30	Basic data applicable to all generators
2:30 – 3:15	Demand response
3:15 – 4:00	Energy storage
4:00 – 5:00	Next steps and Q&A

Agenda

11:00 – 11:10	**Introductions and announcements**
11:10 – 11:30	Introduction to SERVM reliability calculator
11:30 – 12:15	Regions and weather
12:15 – 1:00	Neural networks, load shapes, and wind/solar production profiles
1:00 – 2:00	Lunch
2:00 – 2:30	Basic data applicable to all generators
2:30 – 3:15	Demand response
3:15 – 4:00	Energy storage
4:00 – 5:00	Next steps and Q&A

Safety and emergency information

- In the event of an emergency, please calmly proceed out of the exits. There are four exits total. Two exits are in the rear and two exits are on either side of the public speakers area.
- If you use the back exit, please head out through the courtyard and down the front stairs across McAllister.
- If you use the side exits you will end up on Golden Gate Ave. Please proceed around the front of the building to Van Ness Ave and continue on down to the assembly point.
- Our assembly point is between the War Memorial Building and the Opera Building (House) on Van Ness Ave, between McAllister and Grove.

Today's focus is on assumptions & inputs into ED reliability modeling

- One of approximately 3 planned workshops
- Today we will review and discuss the inputs and assumptions recently published by staff
- We will address additional assumptions and inputs, model outputs, ELCC methodologies, and non-ELCC applications in future staff papers, proposals, and workshops
- Comments due Dec 6 to dbr@cpuc.ca.gov

Agenda

11:00 – 11:10	Introductions and announcements
11:10 – 11:30	**Introduction to SERVM reliability calculator**
11:30 – 12:15	Regions and weather
12:15 – 1:00	Neural networks, load shapes, and wind/solar production profiles
1:00 – 2:00	Lunch
2:00 – 2:30	Basic data applicable to all generators
2:30 – 3:15	Demand response
3:15 – 4:00	Energy storage
4:00 – 5:00	Next steps and Q&A

ED is conducting modeling using the SERVM reliability calculator

- SERVM: Strategic Energy Risk Valuation Model
- Probabilistic model of the WECC system
  - 8 California regions (4 CAISO areas), 10 bordering states/countries
- Main data sources:
  - CAISO MasterFile (where possible) and TEPPC Common Case 2022 dataset (outside of CAISO)
  - Load inputs and fuel price forecasting from the CEC
  - Several inputs (such as outage rates and DR prices) sourced from CAISO 2012 LTPP modeling
- Developed by Astrape Consulting, licensed by ED, installed on CPUC servers, populated and run by ED staff

SERVM models consecutive hours and days based on historical data

- Future study year is modeled based on thousands of probabilistic runs
- Each run is based on a randomly drawn historical weather year, the anticipated generation fleet, forecasted load, and expected uncertainty
- Runs are modeled with 8760 continuous hours, and intra-hour (5-minute) volatility
- Outputs numerous system reliability metrics

SERVM overview

- Can model any year with complete data – depends on data availability
- Several types of resources; each resource modeled individually
- Each region is modeled with full set of generators and loads, including weather and fuel curves
- Outputs 8760 hourly curves for loads and generation

Resource Types in SERVM
(T)hermal
(F)ossil
(N)uclear
(R)enewable
(C)urtailable
(P)umped Storage (used to model all storage)
(H)ydro

Agenda

11:00 – 11:10	Introductions and announcements
11:10 – 11:30	Introduction to SERVM reliability calculator
11:30 – 12:15	**Regions and weather**
12:15 – 1:00	Neural networks, load shapes, and wind/solar production profiles
1:00 – 2:00	Lunch
2:00 – 2:30	Basic data applicable to all generators
2:30 – 3:15	Demand response
3:15 – 4:00	Energy storage
4:00 – 5:00	Next steps and Q&A

Weather data are sourced from public NOAA and NREL databases

- NOAA ISD-Lite Database (DS3505), hourly, 1981-2010
  - Air temperature (degrees Celsius * 10)
  - Dew point temperature (degrees Celsius * 10)
  - Sea level pressure (100s of Pascals)
  - Wind direction (angular degrees)
  - Wind speed (meters per second * 10)
  - Total cloud cover (coded, see format documentation)
  - One-hour accumulated liquid precipitation (millimeters)
  - Six-hour accumulated liquid precipitation (millimeters)
  - Solar irradiance (direct and diffuse) and angle

Weather data are sourced from public NOAA and NREL databases

- U.S. Automated Surface Observing System (ASOS) Station Listing
  - Weather station latitude, longitude, and elevation
- NREL National Solar Radiation Database (NSRDB), 1981-2010
  - Solar irradiance
- NREL wind resource potential data
  - Wind resource potential by height

Regions share weather, generation profiles, load & transmission constraints

- Weather can be used for load & VER production profile generation
- Weather region granularity balances precision, accuracy, and feasibility
- 18 regions across the WECC region
  - Developed by CEC staff
- Primarily based on service territories
- Does not correspond to Local Capacity Areas
- Insufficient granularity for transmission planning

There are 8 California regions and 10 external regions modeled in SERVM

California Regions	External Regions
IID (Imperial Irrigation District) Service Territory	Arizona
LADWP Balancing Authority Area (BAA)	Canada
PG&E Bay Area (Greater Bay Area LCR Area)	Colorado
PG&E Valley (Other PG&E Local Capacity Areas)	Mexico
SCE TAC Area	Montana
SDG&E Service Territory	Nevada
Balancing Authority of Northern California (SMUD)	New Mexico
TID (Turlock Irrigation District) BAA	Pacific Northwest
	Utah
	Wyoming

Regional weather is a weighted average of up to 3 weather stations

- Weather stations and weightings may be different for synthetic load profile generation and for wind/solar production profile generation
- Load profile weather stations are selected and weighted based on load distribution
  - Residential AC penetration (as measured by the Residential Appliance Saturation Survey) is used as a proxy for load distribution
  - In the future, population could be added as a proxy for load distribution in winter months; however, current methods already produce reasonable results
- For wind/solar production profile generation, weather stations could be weighted according to the distribution of the current installed capacity of the relevant technology
  - Staff is still assessing whether a more granular approach may be possible (addressed in later slides)

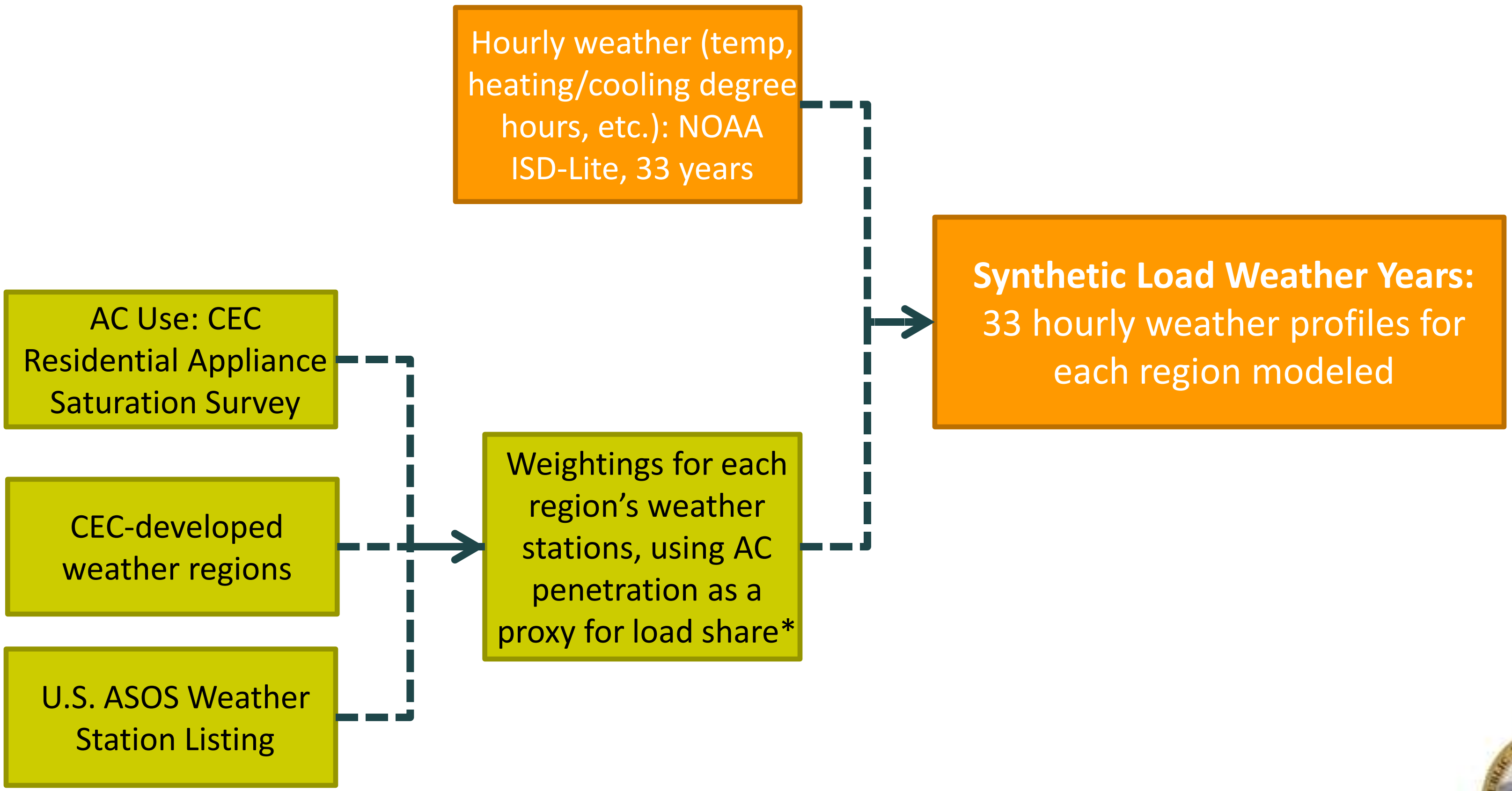
Agenda

11:00 – 11:10	Introductions and announcements
11:10 – 11:30	Introduction to SERVM reliability calculator
11:30 – 12:15	Regions and weather
12:15 – 1:00	**Neural networks, load shapes, and wind/solar production profiles**
1:00 – 2:00	Lunch
2:00 – 2:30	Basic data applicable to all generators
2:30 – 3:15	Demand response
3:15 – 4:00	Energy storage
4:00 – 5:00	Next steps and Q&A

Synthetic load shapes are needed to assess if generation can meet demand

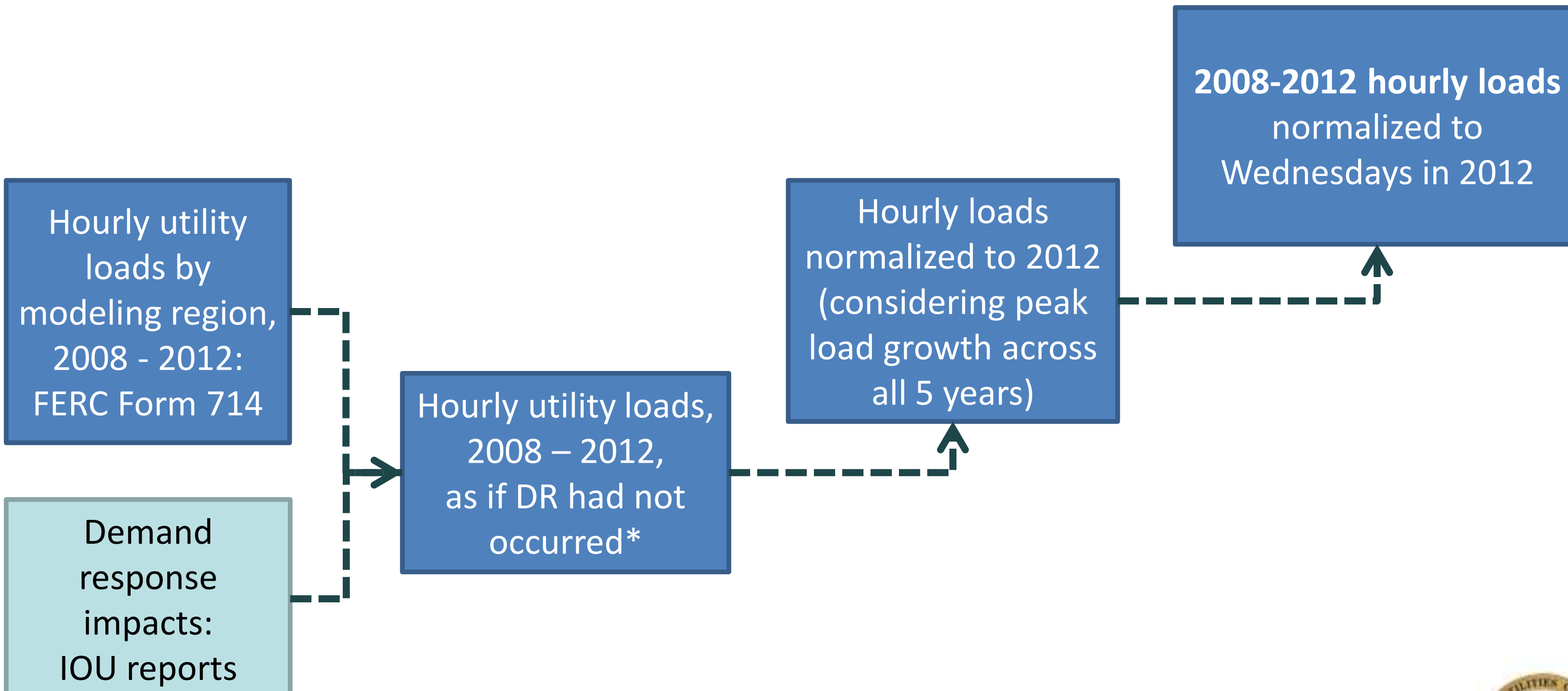
- Load is primarily a function of weather and of economic growth
  - Because weather is highly variable, model iterations test 33 different load profiles, each based on a different historical weather year
- Short-term forecasting and long-term economic uncertainty are also important to consider in generation planning
  - These will be addressed in future papers

Load shapes are generated based on historical, regional weather data



*Within CAISO, when possible given data quality. External to CAISO, applicable stations are simply averaged.

Load shapes are also based on normalized historical load



*DR is added back into IOU loads so that it can later be modeled as a resource.

Neural network modeling relates historical weather to load in a region

2008-2012 Hourly Weather Data
- Hourly temperature (primary variable)
- Hour of day
- 8, 24, and 48-hour previous aggregate temp
- Current heating and cooling degree hours
- 5% and 50% exponentially weighted aggregate temperatures

2008-2012 Hourly Loads
- Without DR
- Normalized to Wednesdays in 2012
- Specific to the regions modeled in SERVM

Predictor File Created: NeuroShell neural network model developed by Ward Systems
- Data are analyzed on a monthly basis (with 15-day overlap across months before & after)
- 10% of data are withheld for testing & verification purposes
- Neural network determines the correlations between weather variables (input) and load (output)
- Result: a predictor file enabling creation of synthetic load profiles for all 33 years of weather data*

*Re-insertion of weekdays and normalization to the modeling study year occurs outside of the predictor.

Neural network load shape modeling: accuracy of results, and a few caveats

- R-squared values of 90% achieved
  - This could be improved in the future through additional calibration
- Neural networks are good at interpolation, but struggle with extrapolation; therefore, extreme temperatures are modeled with a separate regression, outside of the neural network
- Because neural networks predict better when relationships are very consistent, performance is somewhat better in summer, when high heat has a clearer impact on loads

A neural net may also be used for hourly weather-based wind & solar profiles

- Hourly CAISO settlement data can serve as historical technology performance data to train predictor output
- Technologies can be divided into categories with similar responses to weather
  - Settlement data can be normalized across facilities of different sizes and to account for changes in a category's installed capacity over time
- Regions can be modeled with homogeneous weather
  - In addition to NOAA data, NREL's National Solar Radiation Database and wind resource data may be incorporated
  - Stations can be weighted to reflect the geographic distribution of the installed capacity of a given technology category
- The neural network can separately analyze each technology within each region to develop predictor files for each possible combination
  - Results can be reviewed for reasonableness and modified to ensure appropriate volatility levels and correlation between regions

Technology categories would be set based on analysis of performance data

Possible technology categories for wind and solar generation profiles

Wind	Solar
Above/Below 80 Meters	Solar Thermal (with/without storage)*
Above/Below 50 Meters	Rooftop (residential/larger scale)
Older/Newer Vintage	Fixed Tilt (over/under 20 MW)
Utility Scale/Distributed	Tracking

*Because of the unique characteristics of solar thermal generation, it will not be addressed in this workshop; its generation may be modeled using a different methodology.

Other approaches to wind and solar profile development may be possible

- Developers and utilities conduct modeling as part of bid submissions and analyses, and manufacturers publish detailed performance specifications
  - These models and specifications could perhaps be applied based on the historical weather years required for SERVM
- Lawrence Livermore National Laboratory (LLNL) and others are engaged in high resolution weather modeling
  - These weather results could perhaps be utilized to develop more accurate hourly wind and solar generation profiles

Agenda

11:00 – 11:10	Introductions and announcements
11:10 – 11:30	Introduction to SERVM reliability calculator
11:30 – 12:15	Regions and weather
12:15 – 1:00	Neural networks, load shapes, and wind/solar production profiles
1:00 – 2:00	**Lunch**
2:00 – 2:30	Basic data applicable to all generators
2:30 – 3:15	Demand response
3:15 – 4:00	Energy storage
4:00 – 5:00	Next steps and Q&A

Agenda

11:00 – 11:10	Introductions and announcements
11:10 – 11:30	Introduction to SERVM reliability calculator
11:30 – 12:15	Regions and weather
12:15 – 1:00	Neural networks, load shapes, and wind/solar production profiles
1:00 – 2:00	Lunch
2:00 – 2:30	**Basic data applicable to all generators**
2:30 – 3:15	Demand response
3:15 – 4:00	Energy storage
4:00 – 5:00	Next steps and Q&A

Reliability and Economic Dispatch based Modeling

Model dispatches generators to meet reliability needs

- **Minimize outage events**
- **Maintain reserve margin**
- **All generators are dispatched to their capabilities without attention to cost**
- **Use limited resources are dispatched during reliability conditions**

Generators are dispatched economically

- Generators are dispatched according to heat rates and other costs
- Overall cost is tracked and reported
- Use limited resources are sometimes dispatched when cost is high
- Model can turn off economic dispatch logic

Different resource types with different capabilities and data requirements

(T)hermal
(F)ossil
(N)uclear
(R)enewable
(C)urtailable
(P)umped Storage (used to model all storage)
(H)ydro

Inputs common to all types of generators - Inputs specialized to fossil and nuclear types

Common to most types of generators

- Resource Name
- Max and Min Capacity value*
- In service date and retirement (out of service date)
- Location (Region)
- Fuel Type

Variables specialized to Fossil and Nuclear (Types T, F, N)

- Heat rate curves (more than one value)*
- Ramp rate (Single value for each generators)*
- Planned and maintenance outages*
- Fuel price curves
- Variable O&M*
- Startup Cost and Start up Time*

Overall dispatch

*These variables can very monthly, seasonally, or annually

Most Variables sourced from two places

- Variables related to generators inside CAISO are sourced from CAISO MasterFile
- Variables related to generators in California but outside of CAISO sourced from TEPPC Common Case – other options?
- Variables related to generators outside of CAISO sourced from TEPPC Common Case

Agenda

11:00 – 11:10	Introductions and announcements
11:10 – 11:30	Introduction to SERVM reliability calculator
11:30 – 12:15	Regions and weather
12:15 – 1:00	Neural networks, load shapes, and wind/solar production profiles
1:00 – 2:00	Lunch
2:00 – 2:30	Basic data applicable to all generators
2:30 – 3:15	**Demand response**
3:15 – 4:00	Energy storage
4:00 – 5:00	Next steps and Q&A

Demand Response (C Type variables)

Existing ways to characterize C type resources in SERVM	Source
Program name, max MW capacity, region	Program Tariff and Load Impact Reports
Limits on dispatch of program (hours per day, hours per month, hours per year)	
Availability window – weekends/weekdays	
Months of operation in each year	
Emergency triggers	
Dispatch in blocks/partial dispatch	
Dispatch/curtail price	CAISO modeling for LTPP

*Possible to modify SERVM to add additional capabilities, to better reflect existing and potential future DR design

Possible modifications to SERVM

It is also possible to modify SERVM algorithm as needed

Potential ways to characterize C type resources in SERVM	Source
Notification period (Day ahead, day of)	Program Tariff/Load Impact Reports
Weather effects – less response when hot/cold	
Anticipated opportunity cost – will it be needed more later?	
Ramp rate/ramp patterns	
Customer fatigue – decrease in response on 2nd or 3rd day	
More detailed modeling of maximum capacity, to range between 1-in-2 and 1-in-10 values	
Heat rate and other types of triggers	

*Modifications represent additional time/expense

Agenda

11:00 – 11:10	Introductions and announcements
11:10 – 11:30	Introduction to SERVM reliability calculator
11:30 – 12:15	Regions and weather
12:15 – 1:00	Neural networks, load shapes, and wind/solar production profiles
1:00 – 2:00	Lunch
2:00 – 2:30	Basic data applicable to all generators
2:30 – 3:15	Demand response
3:15 – 4:00	**Energy storage**
4:00 – 5:00	Next steps and Q&A

Storage is modeled based on pumped hydro, but parameters can change

Input	Source
Maximum rated discharge	Testing submitted to the CAISO. Test should go from fully charged to minimum allowable charge. Duration should also be reported.
Total usable storage volume	Calculated based on testing: Maximum rated discharge * (discharge test duration)
Maximum rated charge	Testing submitted to the CAISO. Test should go from minimum allowable charge to fully charged. Duration also to be reported.
Round trip efficiency	Calculated based on testing submitted to the CAISO: (discharge MW*duration) ÷ (charge MW*duration)
Capable of supplying non-spinning reserves	Start time testing submitted to the CAISO
Facility in-service dates	CAISO MasterFile, unless utilities have more current information
Scheduled maintenance and maintenance outage periods	Historical data from the CAISO, to be collected over time for new facilities
Real-time price at which storage is dispatched	PPA variable O&M terms plus appropriate ROI value

Storage (P Type resources)

- Since resource type is based on pumped storage hydro – some “workaround” type issues to make it work for other types of storage
  - Dispatch pattern based on sequential charging and generating, where both ends are price responsive
  - Not currently designed for fast charge/discharge oscillation
  - Not currently designed to model co-locating storage with other types of generators or load
  - Even so, it is possible to develop “workarounds”

*Possible to modify SERVM to add additional capabilities – dedicated hours in current contract specifically for SERVM modifications

Possible modifications to SERVM

It is also possible to modify SERVM algorithm as needed

Potential ways to characterize P type resources in SERVM	Source
Ramp rates	No sources identified yet; resources are theoretical
Start up costs/start up patterns	
Planned outage/forced outage logic	
Advance notice requirements	
Opportunity cost values/AS market revenues	

*All modifications represent some contracting expense

Agenda

11:00 – 11:10	Introductions and announcements
11:10 – 11:30	Introduction to SERVM reliability calculator
11:30 – 12:15	Regions and weather
12:15 – 1:00	Neural networks, load shapes, and wind/solar production profiles
1:00 – 2:00	Lunch
2:00 – 2:30	Basic data applicable to all generators
2:30 – 3:15	Demand response
3:15 – 4:00	Energy storage
4:00 – 5:00	**Next steps and Q&A**

Next Steps and Q&A

Additional workshops and methodology/assumptions papers

Assumptions left to discuss	Workshops and Proceeding
Hydropower facilities (Pumped and non-pumped)	Additional workshops in Dec and Jan
Forecast error	Proposal and Modeling Results
Possible work on QF facilities – SRAC price curve	Formal Comments
	Commission Decision on Methodology or Results

*Because of the unique characteristics of solar thermal generation, it will not be addressed in this workshop; its generation may be modeled using a different methodology.

Thank you!
For Additional Information:

www.cpuc.ca.gov

(Search: Resource Adequacy History)